Investigating the Magnetic Fields and Plasma velocity in the Quiet Sun photosphere

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Abstract. The quiet Sun represents the majority of the solar surface outside of sunspots, pores, and plages, containing weak and dynamic magnetic fields whose origins are strongly linked to convective plasma motions. The study investigates the strength and configuration of vector magnetic fields in the quiet photosphere using spectropolarimetric observations from the Solar Optical Telescope (SOT-SP) aboard the Hinode satellite by using the High Altitude Observatory. The vector magnetic fields and plasma velocity were found by using a Milne-Eddington inversion approach where level 1 data was used to produce level 2 data. The mean magnetic field was calculated to lie in the range between 100–200 Gauss, while the photospheric plasma velocities ranged from 0.09–0.10 km/s in the quiet regions.

Introduction

The Sun is a yellow dwarf star located in the center of the solar system. It is a giant ball made of ionized gas, which is called plasma. The Sun is composed of hydrogen (74%) and helium (24%), with all the other elements of the periodic table making up only a total of 2% of the Sun's matter.

The quiet Sun is a region of the solar surface outside of sunspots, pores, and plages. During the solar cycle, the sun appears spotless with fewer or no sun spots when the sun is in its quiet state; we say that the sun is at solar minimum.

Research Objectives

- To calculate the magnetic field strength in the quiet Sun photosphere using solar observational data.
- To determine the line-of-sight plasma velocity using Doppler velocity measurements from the same dataset.
- To compare magnetic field and velocity maps in order to analyze the relationship between plasma motion and magnetic field distribution.

Methodology

- Spectropolarimetric data from Hinode/SOT-SP was used.
  - Level-1 data was calibrated using the SOT-SP preparation package.
  - Milne-Eddington inversion was applied to stokes profiles (I,Q,U,V).

  produced Level-2 data containing vector magnetic fields and Doppler velocities.
- Magnetic field strength and photospheric plasma velocities in the quiet sun.

Results: Magnetic Fields and Plasma Velocity Maps

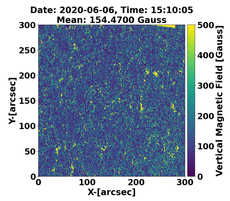

Fig. 1: Magnetic Field Map

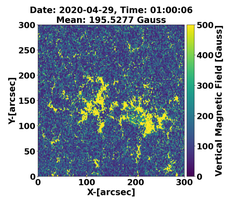

Fig. 2: Magnetic Field Map

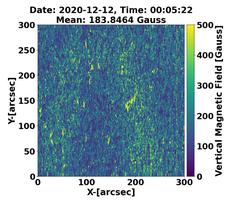

Fig. 3: Magnetic Field Map

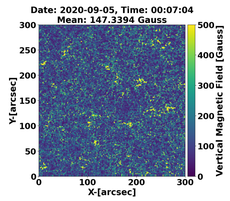

Fig. 4: Magnetic Field Map

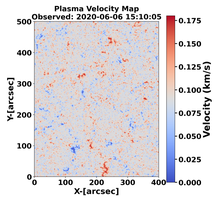

Fig. 5: Plasma Velocity Map

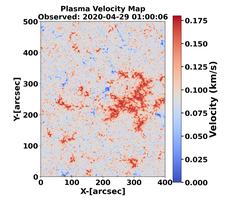

Fig. 6: Plasma Velocity Map

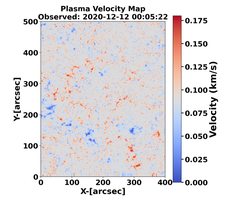

Fig. 7: Plasma Velocity Map

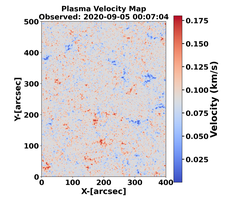

Fig. 8: Plasma Velocity Map

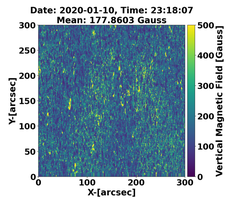

Fig. 9: Magnetic Field Map

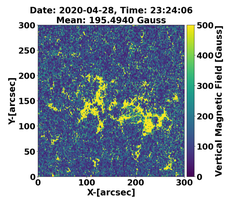

Fig. 10: Magnetic Field Map

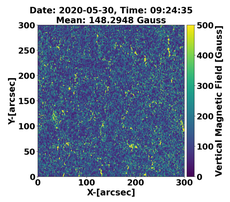

Fig. 11: Magnetic Field Map

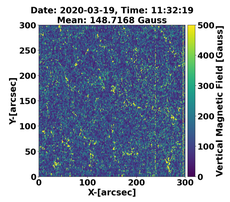

Fig. 12: Magnetic Field Map

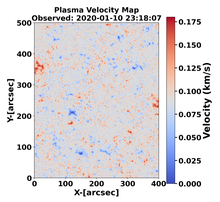

Fig. 13: Plasma Velocity Map

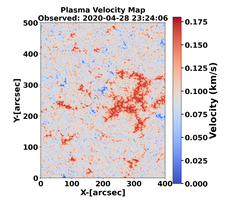

Fig. 14: Plasma Velocity Map

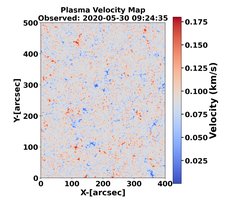

Fig. 15: Plasma Velocity Map

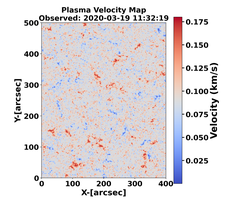

Fig. 16: Plasma Velocity Map

Discussion

- The magnetic field strength in the quiet Sun photosphere was found to range between 100–200 G, indicating the presence of weak magnetic fields in these regions.
- The plasma velocity was calculated to be between 0.09–0.10 km/s, showing small but significant plasma motions in the photosphere.
- The magnetic field maps show that brighter colors correspond to stronger magnetic field regions.
- The velocity maps indicate that brighter colors represent areas with higher plasma velocity.
- These observations suggest that plasma motions may influence the distribution and evolution of small-scale magnetic fields in the quiet Sun.

Conclusion

- Successfully quantified the magnetic and dynamic properties of the quiet Sun photosphere using Hinode/SOT-SP spectropolarimetric data.
- Identified a mean magnetic field strength ranging between 100–200G.
- Determined photospheric plasma velocities to be in the range of 0.09–0.10 km/s.
- Demonstrated that "quiet" regions harbor significant magnetic activity strongly linked to convective plasma motions.
- Established a baseline for understanding small-scale magnetic field distribution and its role in solar atmospheric dynamics.

References

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